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(54) Ball valve

(57) A floating ball valve has seat rings (102) disposed on diametrically opposite sides of the ball (C), a frusto-conical disc spring (104) mounted between each seat ring and an associated valve body shoulder to urge the seat rings into engagement with the ball and a reinforcing ring (100) disposed at the forward end of each seat ring to act as a rigid bearing surface. A groove may be formed in the rear face (122) of the seat ring (102) to facilitate flexure thereof when the seat ring is made of acetal resin, rather than PTFE.

FIG. 3

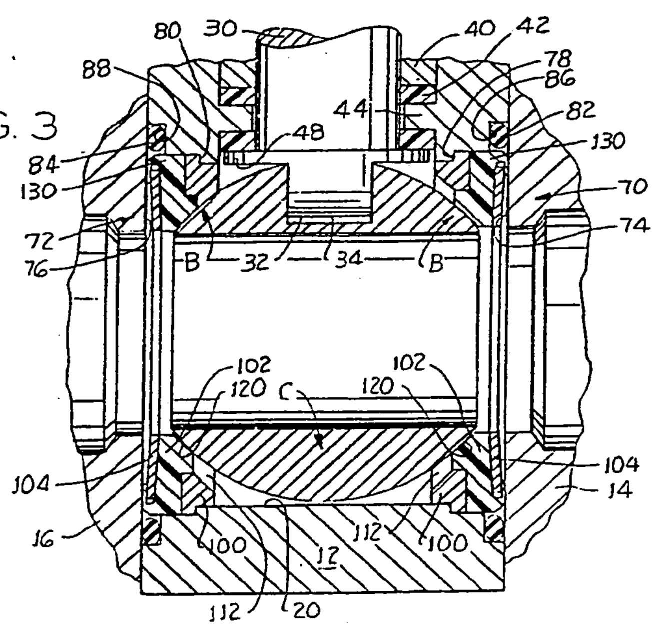

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FIG. 1

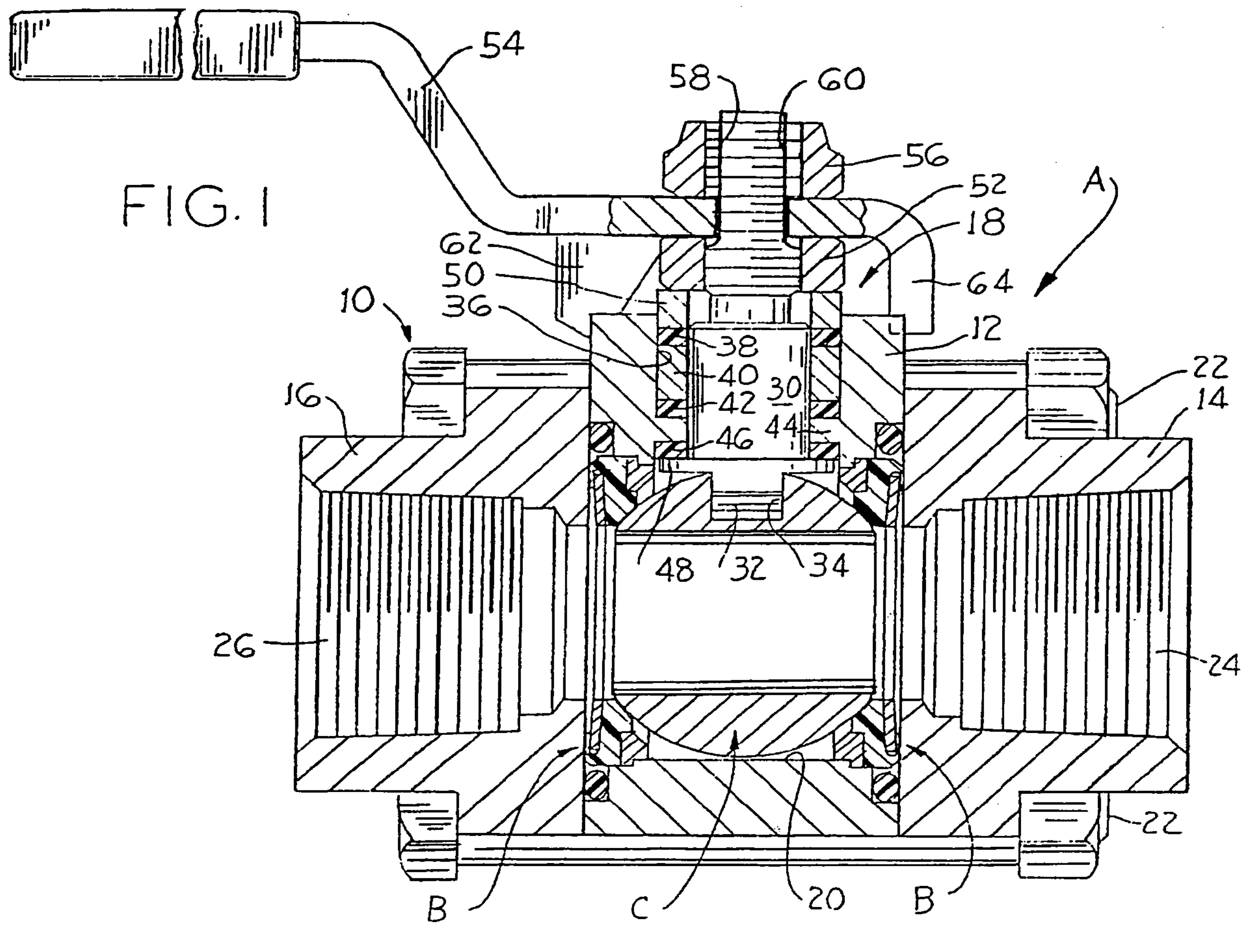

54
58
60
56
52
A
18
62
50
64
36
10
38
12
40
30
22
16
42
14
44
46
48
32
34
26
24
22
B
C
20
B

FIG. 2

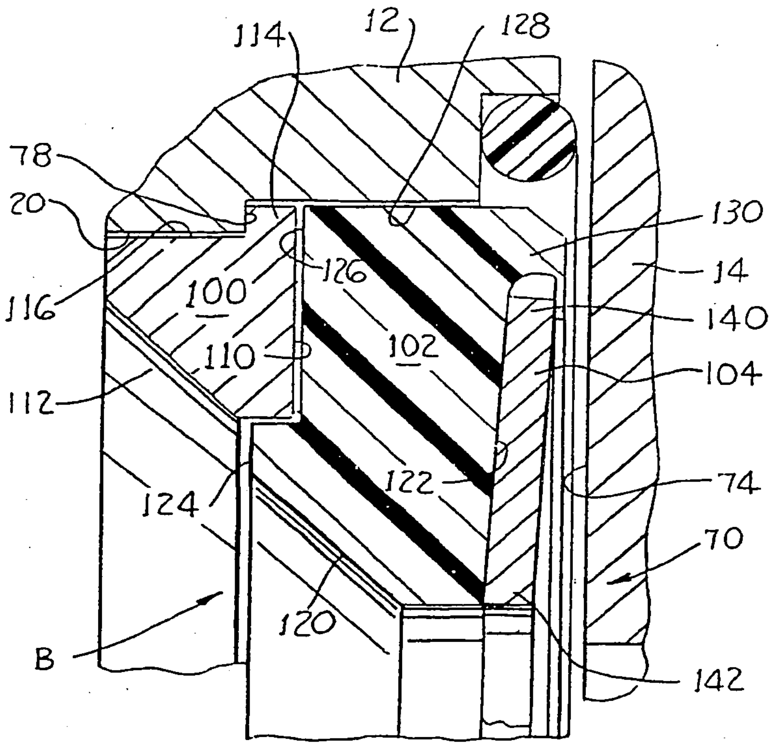

114
12
128
78
20
130
126
14
116
100
140
102
110
104
112
122
74
124
70
120
B
142

FIG. 3

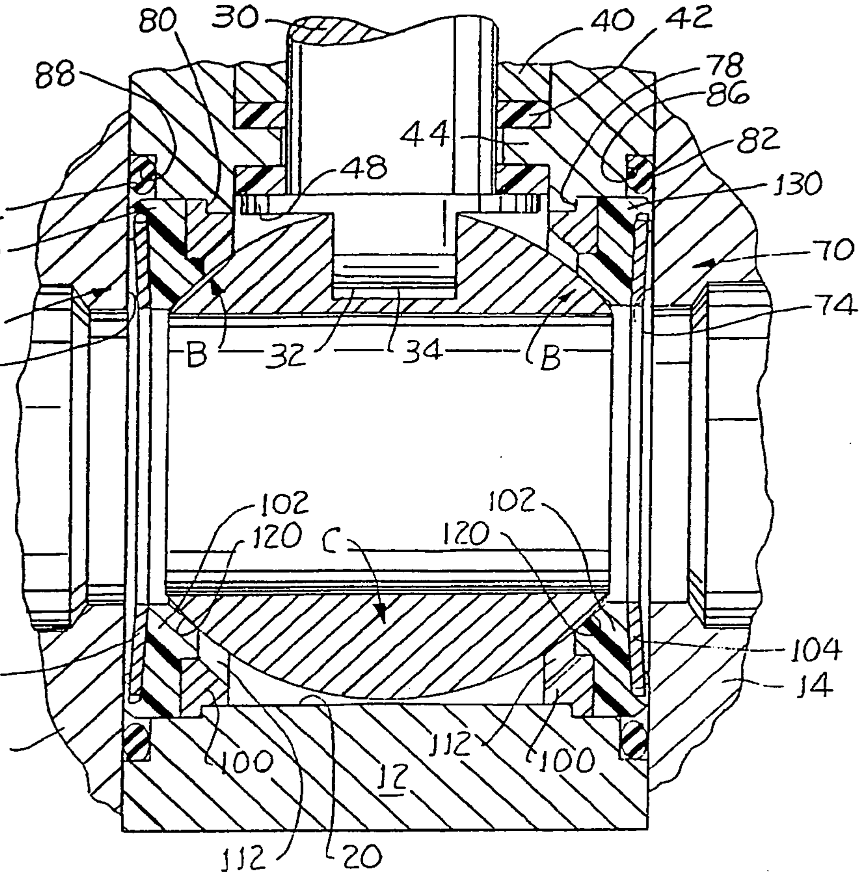

30
80
40
42
88
78
86
44
82
48
84
130
130
70
72
74
76
B
32
34
B
102
102
120
120
C
104
104
14
16
112
100
100
12
112
20

FIG. 4

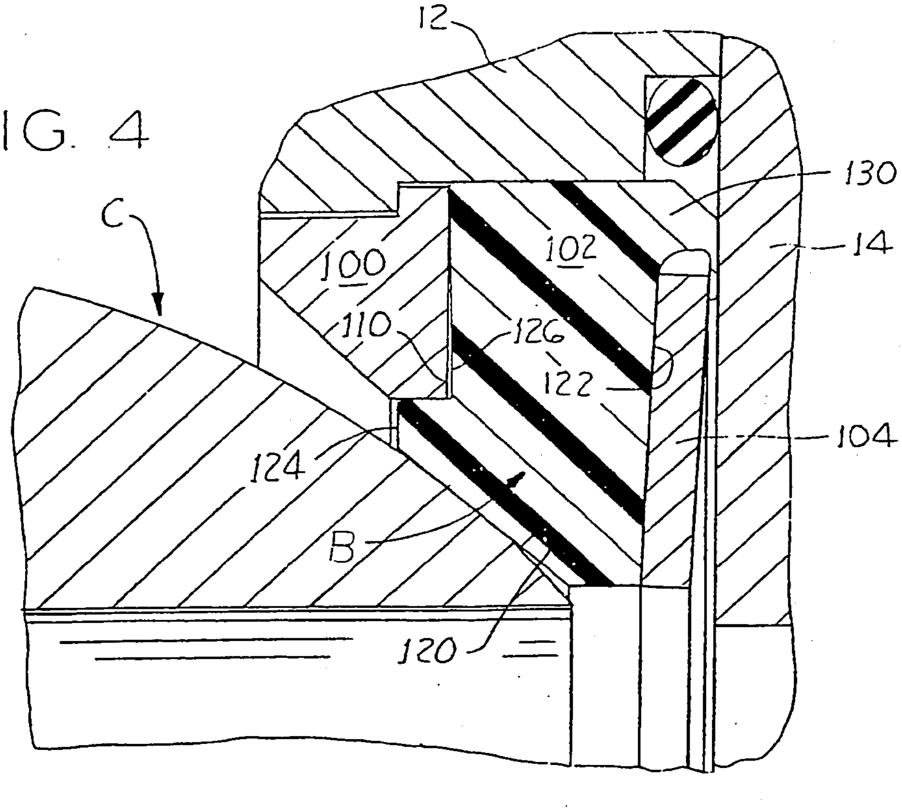
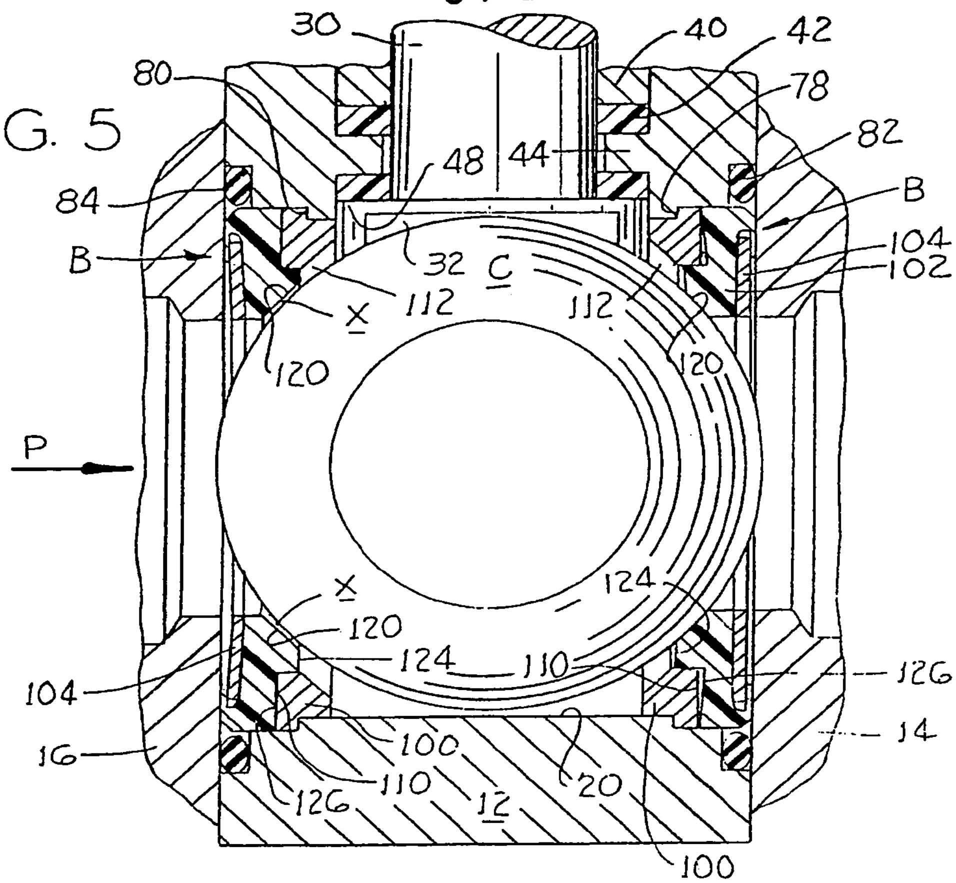
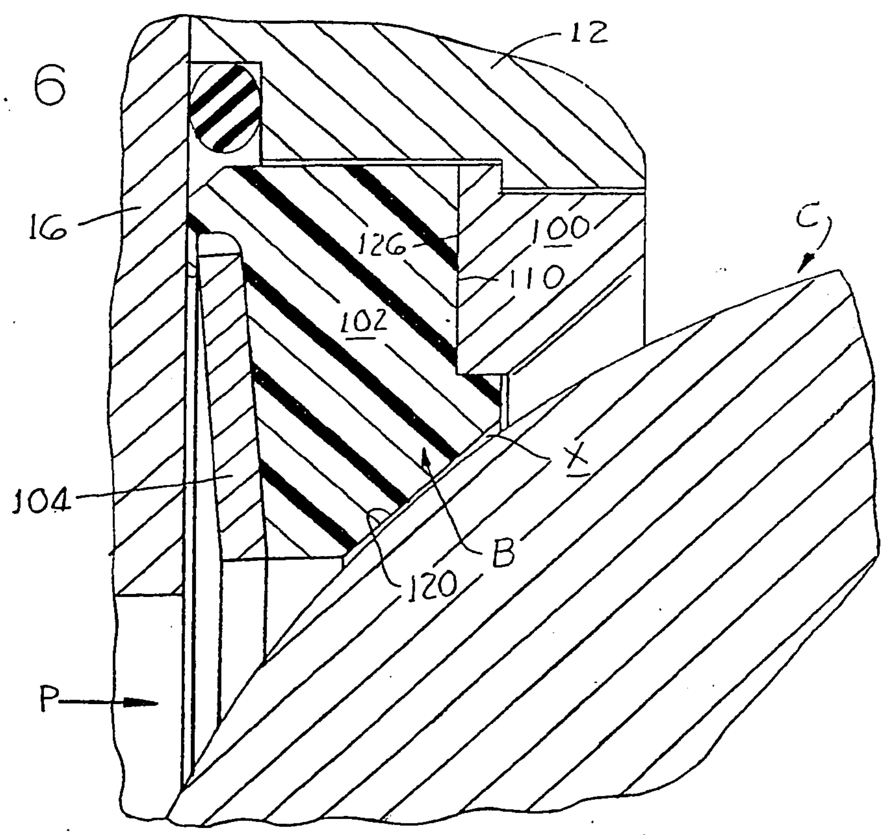

12
130
C
100
102
14
110
126
122
104
124
B
120

FIG. 5



30
40
42
80
78
82
48
44
84
B
B
104
102
32
C
112
X
112
120
120
P
X
124
120
104
124
110
126
100
14
16
110
20
126
12
100

FIG. 6



12
16
126
100
110
C
102
X
104
B
120
P

FIG. 7

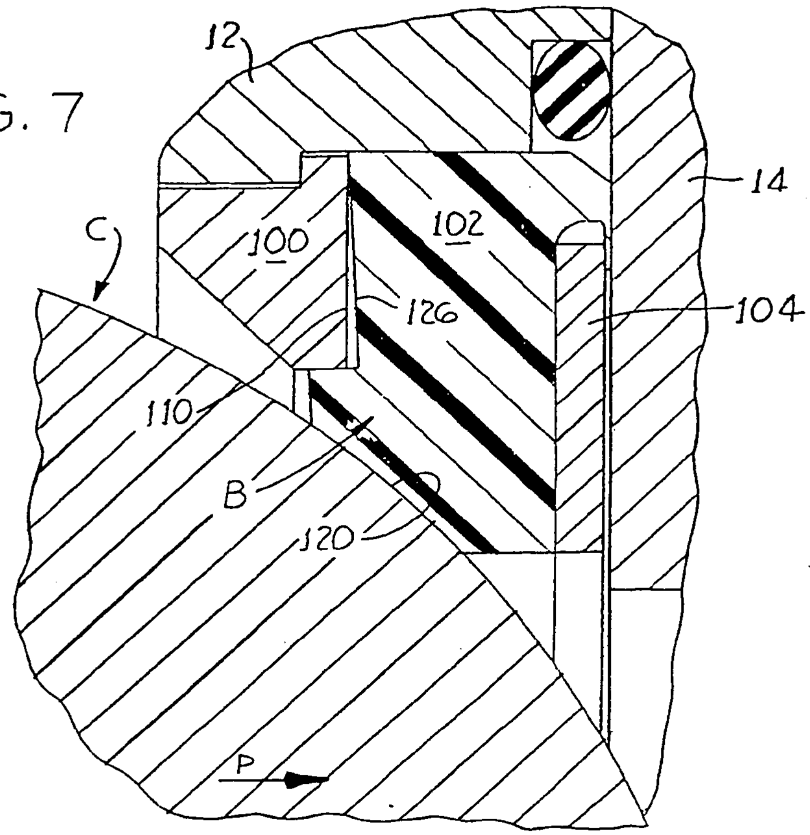
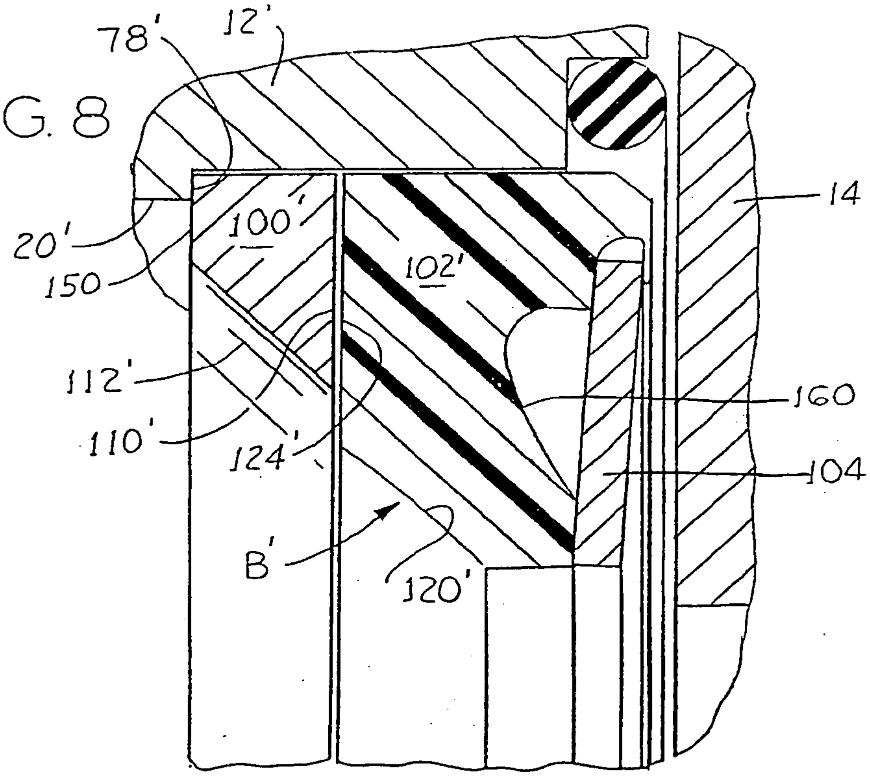

12
14
C
100
102
104
126
110
B
120
P

FIG. 8


78'
12'
14'
100'
102'
20'
150
112'
110'
124'
160
104'
B'
120'

SPECIFICATION
Ball valve

This invention relates to ball valves.

The invention is particularly applicable to ball valves of the type having a so-called floating ball and will be described with reference thereto. However, it will become readily apparent to those skilled in the art that the invention is capable of broader applications and could be adapted for use in other types and styles of valves.

Typical ball valve constructions in commercial use employ annular seats or seat rings formed of a resilient and deformable plastics material. Two such seat rings are positioned in engagement with and on opposite sides of the ball member about the valve body inlet and outlet openings. Normally, the seats are designed to engage the ball with narrow band or line contact and to flex slightly under loads. The ball itself is mounted for a slight amount of free movement or shifting axially of the seat when the ball is in a valve-closed position under fluid pressure conditions. Such shifting causes the ball to act against and flex the downstream seat ring to enhance its sealing engagement with the ball. The amount of such flexing varies in accordance with the fluid pressure involved.

With increasing fluid pressure and resultant downstream shifting of the ball, the ball is moved away from the upstream seat. The ball contact with the upstream seat may or may not be broken, depending upon the pressure and/or seat design. Some designs intentionally seal at the upstream seat while others deliberately prevent an upstream seal and do all the sealing on the downstream seat. Moreover, some ball valve designs utilize spring-biasing means for continuously urging the opposed seat rings towards each other and into sealing engagement with the ball.

Small ball valves, that is, valves of 25 mm and under, and low pressure ball valves are usually made with end-loaded seats and a floating ball as described above. This is typical of small ball valve designs for two primary reasons. The shut-off pressure acts on the total seal diameter, either the outer diameter of contact between the ball and downstream seat or the outside diameter of the inlet seat. The total force (fluid pressure × area) must be carried by the ball. With a floating type ball, all the force is applied to the downstream seat and since the seat comprises an annulus of a smaller area, seat stress is always greater than the fluid pressure. At very high fluid pressures, the seal force crushes ordinary plastics type seats. Also, as the valve size increases, the ball force increases as a function of the square of the seal diameter whereas the annular seat does not increase in area at the same rate. Therefore, alternative valve constructions must be employed to overcome these problems. To that end, large ball valves, that is, valves over 50 mm and high pressure ball valves are usually constructed with a trunnion-supported ball. The valve seats float and are pressure-activated to seal against the ball. Large valves must have a trunnion-mounted ball to avoid overstressing of the seat even at low pressures.

Existing valve designs have taken the approach of minimizing the seat area by sealing on the downstream seat only. This reduces the effective area to considerably less than the full outside diameter of the inlet seat. However, if identical seats are used both upstream and downstream, this requires that the seat be designed to leak with upstream pressure, but seal with downstream pressure. This has two disadvantages. First, to not seal at the upstream seat, there must be a way for pressure to bypass the inlet seat. This means the downstream seat must have two dynamic seals, i.e., one against the ball and another to seal the bypass. Usually, this involves an additional mechanism for sealing the seat against the downstream flange or fitting. Obviously, the use of two seal points provides a less reliable arrangement than a single seal. Second, if the inlet seat is bypassed, it cannot apply any force to the ball to hold it against the downstream seat at low pressure. The weight of the ball causes it to fall below the seat centreline and allows fluid leakage at low pressure. This problem becomes more significant with larger valves because the weight of the ball increases with the cube of the nominal size. Thus, a valve having a floating ball should have seats which are firmly held against the ball without system pressure so that a seal is formed regardless of how low the pressure may be. As noted above, this has been accomplished by placing a disc spring behind each seat. This feature not only provides a low pressure seal, but also assures an upstream seal at high seat loads.

An upstream seal, however, creates a second problem which also becomes more pronounced as valve size increases. While the valve is being opened, this seat must span the hole or fluid opening through the ball. With a small ball and opening, the seat is quite rigid when loaded as a beam in bending and can easily bridge the gap. As the valve size and opening increase, the section modulus of the seat does not proportionately increase to retain the same stiffness. Thus, the seat may deflect further into the ball opening. Similarly, the outside diameter of the seat ring is normally supported only by a shoulder in the valve body. The area of the seat and, therefore, the force acting on it, increases as the square of the diameter. Since the supporting shoulder is usually quite narrow and its area is more closely related to the seat circumference, the supporting shoulder only increases in a linear fashion. Here also, the problem becomes more pronounced as the valve size increases.

It has, therefore, been desired to develop a ball valve and seat assembly which facilitate use of a floating ball in connection with higher system pressures than have heretofore been possible. Such a design would, in many cases, eliminate the necessity for utilizing trunnion-mounted balls. Trunnion mountings are not considered practical unless the valve is quite large because their use

substantially increases the size, complexity and cost of the valve.

The present invention provides a ball valve comprising a ball valve comprising a valve body having a generally cylindrical fluid flow passageway; a ball member disposed in said passageway and mounted for selective rotation between valve-opened and closed positions with said ball member being shiftable generally axially in said passageway under fluid pressure conditions, at least when said valve is in said closed position; a pair of annular seat rings disposed in said passageway on opposite sides of said ball member between said ball member and an associated valve body shoulder; and an annular disc spring interposed between each seat ring and its associated shoulder for continuously urging said seat rings towards sealing engagement with said ball member; each seat ring having a first continuous surface generally facing said ball member and adapted for positive sealing engagement therewith and a second surface generally facing the associated shoulder with the respective disc spring interposed between each seat ring second surface and its associated shoulder; each disc spring having a generally frusto-conical configuration in its unstressed condition with its smaller diameter end pointing towards said ball member and being sized so that, when said ball member, seat rings and disc springs are assembled between said shoulders, said seat ring first surfaces sealingly engage the surface of said ball member with said seat rings being rotatably flexed slightly outwardly of each other and with said disc springs being partially stressed towards a flattened configuration for continuously urging said seat ring first surfaces towards engagement with said ball member; and so that, when said ball member is axially shifted in said passageway towards one of said valve body shoulders in response to fluid pressure acting thereon in said valve-closed position, the seat ring associated with said one shoulder (the downstream seat ring) is further rotatably flexed towards said one shoulder with the first surface thereof remaining in sealing engagement with said ball member and the disc spring associated with said downstream seat ring is further stressed towards a flattened configuration, the other seat ring (the upstream seat ring) being rotatably flexed towards said ball member in the direction of shifting thereof under the influence of its associated disc spring in order that said upstream seat ring first surface will be urged towards continued contact with said ball member.

Thus, the ball valve has a pair of seat ring assemblies each of which is flexible in one direction of travel and generally rigid in the opposite direction. They are continuously urged towards the ball for maintaining it properly positioned in the valve body and to provide valve sealing regardless of how low the fluid system pressure may be. When the valve is closed, the system pressure moves or shifts the ball downstream towards the downstream seat assembly so that it is further deflected against the associated disc spring. The upstream seat ring is simultaneously urged towards continued engagement with the ball by the disc spring operably associated therewith. In response to a predetermined system fluid pressure, the disc spring associated with the downstream seat assembly is fully deflected and the ball is moved away from engagement with the upstream seat assembly.

More specifically, the invention includes a ball valve comprising a valve body which has a centrally disposed generally cylindrical passageway; a ball member disposed in said passageway and having a fluid flow opening therethrough, said ball member being mounted for rotation about an axis generally normal to said passageway between valve-opened and closed positions to control fluid flow therethrough; a pair of radially inwardly extending shoulders in said passageway disposed generally equidistantly from said ball on opposite sides thereof, each of said shoulders being circumferentially continuous and having a surface facing said ball generally normal to said passageway; a pair of reinforcing rings fixedly positioned axially in said passageway on opposite sides of said ball, said reinforcing rings each having a central opening, a first surface facing an associated one of said shoulders and a second surface generally facing said ball member in a spaced relationship therefrom; a seat ring member interposed between each shoulder and its associated reinforcing ring, each of said seat rings having a central opening, a first continuous surface facing said ball member, a second surface generally facing the associated shoulder and a third surface engageable with the associated reinforcing ring first surface, said seat ring first surfaces being adapted for positive sealing engagement with said ball member; and a disc spring interposed between each seat ring second surface and the associated shoulder, each disc spring having a central opening and a generally frusto-conical configuration in an unstressed condition, said disc springs being positioned with their smaller diameter ends pointing towards said ball member and sized so that, when said ball member, reinforcing rings, seat rings and disc springs are assembled between said shoulders, said seat ring first surfaces sealingly engage the surface of said ball member and cause flexure of said seat rings slightly outwardly of each other in response to such engagement and so that said disc springs are partially stressed towards a flattened condition for continuously urging said first surfaces towards engagement with said ball member.

When the ball member is axially shifted in the passageway towards one of the valve body shoulders in response to fluid pressure acting thereon when the valve is closed, the downstream seat ring associated with the one shoulder is further flexed towards the one shoulder with the first surface thereof remaining in engagement with the ball member and the disc spring associated

with the downstream seat ring is further stressed towards a flattened configuration. The other or upstream seat ring is flexed towards the ball member in the direction of shifting thereof under the influence of its associated disc spring in order that the upstream seat ring first surface will be urged towards continued contact with the ball member. The downstream seat ring associated with the one shoulder may be flexed by shifting movement of the ball member in engagement with the seat ring first surface to a position where the associated disc spring is stressed to a substantially flattened configuration. In that condition, the ball member has been moved away from contact with the first surface of the upstream seat ring. In the preferred arrangement of the invention, the seat rings experience rotational type of flexure in response to engagement with and/or shifting of the ball.

The first surface on each reinforcing ring provides a rigid bearing surface for the associated seat ring to prevent seat ring distortion and displacement in the passageway. The provision of a rigid bearing surface is of significant value for the upstream seat ring when the valve is closed and exposed to elevated system pressures and when the valve is moved from a closed to an open position under such elevated pressures.

The reinforcing rings can be positively located in the valve body passageway by engagement with the end walls of passageway counterbores. In one case, the reinforcing rings may have radially outward extending flanges which engage the counterbore end walls. Alternatively, the inner end walls of the reinforcing rings may engage the counterbore end walls.

Each seat ring second surface further may have therein a groove extending therearound. Such grooves facilitate flexure of the seat rings during valve operation under varying fluid pressure conditions.

The seat rings may be formed or constructed from a wide variety of materials.

The invention will be further described, by way of example, with reference to the accompanying drawings, wherein:

Figure 1 is a cross-sectional view through a ball valve in accordance with a preferred embodiment of the invention;

Figure 2 is a fragmentary, larger-scale cross-sectional view of the preferred seat assembly construction shown just prior to valve make-up and with the ball member removed for ease of illustration;

Figure 3 is a slightly larger scale view of a portion of the valve of Figure 1, showing the ball in the valve opened position under a no-load condition;

Figure 4 is a larger scale fragmentary cross-sectional view of a portion of a seat assembly when the valve is in the opened position of Figure 3;

Figure 5 is a view similar to Figure 3 with the ball member in the valve-closed position under an elevated fluid pressure condition;

Figure 6 is a larger scale fragmentary cross-sectional view showing a portion of the upstream seat assembly when the valve is in the closed position of Figure 5;

Figure 7 is a larger scale fragmentary cross-sectional view of a portion of the downstream seat assembly when the valve is in the closed position of Figure 5; and

Figure 8 is a cross-sectional view, similar to Figure 2, showing a seat assembly which includes various alternative design features.

Referring now to the drawings, Figure 1 shows a ball valve A having a pair of opposed seat assemblies B disposed on opposite sides of a floating type spherical ball member C.

More particularly, and with reference to Figures 1 and 3, ball valve A includes a body or housing 10 having a main or central body section 12 and opposed end fittings 14, 16. Seat assemblies B and ball C are centrally mounted within main body section 12 with the ball member being arranged for selective rotation by a stem and actuating handle assembly 18.

The details of all portions of the valve illustrated in Figures 1 and 3, except for the ball and seat ring assemblies, may be modified as desired and/or necessary to accommodate different types or styles of ball valve constructions. In general, however, and for purposes of describing the present invention, the valve body includes a generally cylindrical central passageway or axially extending fluid flow opening 20 which is only slightly larger in diameter than ball C. Each end fitting 14, 16 is releasably connected to central body section 12 by a plurality of longitudinally extending tie bolts 22 (Figure 1). The end fittings are also provided with internal threads 24, 26 or any other convenient means to enable the valve to be connected to an associated fluid system or piping.

The steam and actuating handle assembly 18 includes a stem 30 whose lower end 32 is shaped as shown for sliding receipt in a slot or groove 34 in the top of ball C. This arrangement allows the ball to be rotated between valve-opened and closed positions while at the same time permitting the ball to have some freedom of movement for shifting axially in valve body passageway 20 when the valve is in a closed position.

Stem 30 extends outwardly through an opening 36 in central body section 12. Packing rings 38, 40 and 42 are positioned in opening 36 and sealingly engage the opening and stem member 30. As shown, lower packing ring 42 rests upon an inwardly extending flange 44 formed within opening 36. A split thrust washer 46 is positioned below flange 44 and is clamped thereto by an outwardly extending shoulder or flange 48 formed at the base of stem 30. The stem is held in position by a packing gland 50 and a packing nut 52. As shown in Figure 1, tightening of packing nut 52 applies pressure to packing rings 38, 40, 42 to assure a fluid tight seal about the stem.

Although it is possible to actuate the valve

stem by many different types of actuators, including both manual and automatic, a handle 54 has been shown. This handle is releasably secured to stem 30 by a nut 56 which clamps the handle to the top of packing nut 52. Co-operating flats 58, 60 are advantageously formed in the handle opening and on the exterior of the stem outer end for properly positioning the handle on the stem. Moreover, the position of the handle and, in turn, the position of ball member C are limited by depending stop members 62, 64 carried by handle 54. These stop members engage suitable surfaces on central body section 12 to provide fixed stops for the valve in the fully-opened and fully-closed positions.

With continued reference to both Figures 1 and 3, the seat ring assemblies B are clampingly maintained in position on opposite sides of the ball member C adjacent opposite ends of the central body section passageway or opening 20. In the preferred embodiment here under discussion, the seat ring assemblies are located substantially equidistantly on diametrically opposite sides of the axis of rotation of the ball member. While the seat ring assemblies could be maintained in position by many different or alternative arrangements, they are shown in the preferred embodiment as being located by shoulders 70, 72 defined by end faces 74, 76 of end fittings 14, 16, respectively. The inward limit of movement of the seat ring assemblies is defined by a pair of shoulders 78, 80 which are formed by the inner end walls of counterbores extending inwardly of valve body passageway or opening 20. Still further, a seal is provided between central body section 12 and end fittings 14, 16 by means of O-rings 82, 84 which are received in second counterbores 86, 88, respectively. Each O-ring is disposed about the outer circumference or outer peripheral surface of a portion of the associated seat ring assembly B.

The structural details of ball valve A described hereinabove are with reference to the preferred valve construction. It will be readily apparent to those skilled in the art, however, that modifications may readily be made thereto to accommodate particular operational needs and/or requirements. Such changes do not affect the scope of the present invention as will be described in detail hereinafter.

Figure 2 shows a cross-sectional view of the seat assembly disposed at end fitting 14, it being appreciated that the other assembly is identical thereto unless otherwise specifically noted. Also, ball member C has been omitted for ease of understanding and appreciating the seat assembly construction.

Each seat assembly is preferably comprised of three components, i.e., a reinforcing ring 100, a seat ring 102 and a frusto-conical disc spring 104. Reinforcing ring 100 has an annular configuration and is desirably constructed from a rigid material, such as steel or other metal. Reinforcing ring 100 has a first continuous surface or end face 110 which faces the associated shoulder 70 of end fitting 14. A second continuous surface 112 faces generally towards the ball member (not shown) but is dimensioned to be spaced therefrom in order to prevent any contact or interference therewith. A radially outwardly extending flange 114 is configured and dimensioned to engage shoulder 78 in central body section passageway 20 to establish a positive forwardmost or home position for the reinforcing ring. The outer circumference or peripheral surface 116 of ring 100 is disposed close to the wall of passageway 20.

Seat ring 102 also comprises an annular or ring-like member having a central opening therethrough. A first continuous ball-engaging surface 120 initially has a generally frusto-conical conformation concentric with the seat ring itself. A seat ring second surface 122 generally faces the associated shoulder 70 of end fitting 14. A third surface 124 faces reinforcing ring first continuous surface 110 and is conveniently stepped as at area 126 radially inwardly from its outer peripheral surface 128. This stepped area is dimensioned and configured to be received over a portion of the reinforcing ring and to engage first continuous surface 110 thereof. As will become more readily apparent, surface 110 acts as a bearing surface to provide rigid support for the upstream seat ring during exposure to fluid pressure.

A flange or lip 130 extends axially outwardly of surface 122 generally at outer peripheral surface 128. This lip or flange is preferably continuous about the seat ring and so located that its radially inner surface generally corresponds to the outside diameter of conical disc spring 104. Flange or lip 130 is bevelled at the radially outermost region thereof and is rolled over the radially outer edge of the disc spring in the manner shown. While not necessary, this arrangement advantageously maintains the seat ring and disc spring together as a subassembly.

In the preferred arrangement of the invention, seat rings 102 are constructed from a resilient plastics material, such as polytetrafluoroethylene. However, other types of materials such as acetal resins could also be advantageously utilized. The particular material chosen will, to some extent, be dependent upon the operating conditions to which the valve is to be subjected. Moreover, various design modifications may be incorporated into the seat assembly components as will be described hereinafter with reference to Figure 8.

The diameter of the outer rim 140 of the frusto-conical disc spring 104 is such that the disc spring may be received within the cylindrical cavity defined by the inner wall of seat ring axial flange 130 and second surface 122. The inner diameter of the spring at its inner rim 142 is substantially equal to the diameter of the opening through the seat ring.

The spring 104 is selected so that its force is sufficient under partial deflection to continuously urge the seat ring towards the ball and towards bearing engagement with surface 110 of

reinforcing ring 100. The spring must also allow stressing or compression thereof towards a flattened condition to accommodate ball shifting in engagement with seat ring first surface 120. In the preferred embodiment here under discussion, seat ring second surface 122 is configured so as to partially stress disc spring 104 when the seat ring and disc spring are joined as a sub-assembly. Such partial stressing is approximately equal to one half of the distance from the free state towards the fully stressed or substantially flattened configuration. However, it should be appreciated that this stressing is not necessary to satisfactory operation of seat assemblies B and the presence or absence thereof is a function of the relative dimensional characteristics between seat ring second surface 122 and disc spring 104.

Disc spring 104 advantageously accommodates generally rotational (rolling) flexure of the seat ring at least until the spring has been moved to a substantially flattened condition. Such operation provides for improved valve sealing results in a manner to be described. Depending upon the type, size and style of ball valve involved, conical disc springs 104 may be advantageously constructed from a number of different metals which have spring properties falling within an acceptable range.

Figure 3 shows the valve in a fully assembled valve-opened position (no load fluid pressure condition). In this position, the two seat assemblies B have been shifted from the unstressed condition shown in Figure 2 to a partially stressed condition. Sizing of ball member C, seat assemblies B and shoulders 70, 72 is such as to provide this relationship at ball valve assembly or make-up.

More particularly, and with continued reference to Figure 3 as well as with reference to Figure 4, the seat assemblies are moved such that opposed seat rings 102 are slightly rotatably flexed away from each other generally about their outer peripheries and against disc springs 104 in response to engagement between seat ring first surfaces 120 and ball member C. This action slightly compresses the associated disc springs towards a flattened condition. In the position of Figure 3, the disc springs are preferably deflected through approximately half of their available travel. In addition to positioning the ball member, this spring deflection assures a seal force between the two seat rings and ball at first surfaces 120 regardless of how low the system pressure may be. It also assures that the seat ring disposed adjacent the valve inlet with form a seal with the overall seat load being dependent upon the area of the seat ring outside diameter.

Figure 4 shows the downstream seat assembly B which is disposed at end fitting 14 when the valve is in the opened position of Figure 3. In this valve position, the upstream seat assembly associated with end fitting 16 assumes a substantially identical relationship. As there shown, frusto-conical seat ring first or ball-engaging surface 120 is in sealing engagement with the surface of the ball member C. The ball member slightly deforms a portion of surface 120 so that at least that portion has a concave spherical conformation. Simultaneously, seat ring 102 is rotatably flexed against disc spring 104 so as to slightly compress the disc spring. Because of the rotational flexing of seat ring 102, the surface of seat ring stepped area 126 is moved away from a contacting relationship with reinforcing ring first surface 110.

Figure 5 shows the valve in a closed position under elevated fluid pressure conditions with the direction of fluid pressure being designated by arrow P adjacent the valve inlet. Depending upon the system pressure, the ball is forced to shift axially of passageway 20 towards the outlet or downstream seat assembly. As a result of this shifting, the seat ring of the upstream seat assembly will be moved back towards its original unstressed conformation as shown in Figure 6 under the influence of the associated disc spring 104. Thus, the upstream seat ring is rotatably flexed or shifted towards the ball as the ball moves downstream. At the same time, the outlet seat ring is further shifted or rotatably flexed in the downstream direction as shown in Figure 7 to further compress its associated disc spring. Up to this point, both seat rings are approximately equally flexible with deflection occurring across the full annulus of the seat from the outside diameter to the inside diameter.

Once the inlet seat deflects back to its original unstressed condition, it changes from a flexible to a much more rigid member. In this condition, the surface of seat ring stepped area 126 bears against first surface 110 of the associated reinforcing ring (Figure 6). The aforementioned bearing engagement virtually stops the inlet seat from any further movement towards the ball as the system pressure continues to increase. On the other hand, the downstream seat ring assembly remains flexible and continues to rotatably flex until the associated disc spring is moved to its substantially fully flattened configuration (Figure 7).

As the downstream seat ring is rotatably flexed, and with the seat ring constructed from polytetrafluoroethylene or the like, ball member C further deforms first or ball-engaging surface 120 thereof so that an increasing surface portion assumes a concave spherical conformation. In the preferred structural arrangement here described, substantially all of first surface 120 will matingly engage the ball member when the downstream disc spring is fully stressed. This relationship is shown in Figure 7. A lesser amount of deformation in first surface 120 would be present in those cases where the seat ring is constructed from harder materials such as acetal resins. When ball member C has shifted an amount to substantially fully deflect the downstream disc spring, the ball member is moved away from all contact with ball-engaging surface 120 of the upstream seat ring. A gap *x* (Figures 5 and 6) is formed therebetween and no sealing whatsoever occurs on the

upstream side of the ball.

This result minimizes downstream seat loading and wear and reduces the turning torque required to rotate ball member C back to the valve-opened position. Within the predetermined operational limits of the valve, ball-engaging surface 120 of the downstream seat ring will not generally be substantially further deformed due to system pressures from the conformation generally shown in Figure 7. Substantial further deformation could undesirably cause the downstream seat ring to break down and/or be completely destroyed.

Reinforcing ring 100 associated with the upstream seat assembly prevents failure of the associated seat ring 102 by providing a large bearing surface so that the bearing stress will only be approximately 1 1/2 to 2 times the fluid system pressure. This bearing stress is well within the capabilities of most plastics materials utilized in constructing ball valve seat rings. Moreover, and as the valve approaches the opening point, i.e., when the ball C is rotated from the position shown in Figure 5 back to the position shown in Figure 3, only seat ring ball-engaging surface 120 must span the ball opening. This greatly reduces the unsupported area and length of the span. First surface 110 of the reinforcing ring also provides support substantially across the entire span of upsteam seat ring third surface 124. The combined effect of support across the ball opening and a wide bearing shoulder at seat ring stepped area 126 prevents the upstream or inlet seat ring from distorting. It is essential to prevent such distortion in order to preclude subsequent damage to the downstream seat ring. When an unsupported upstream seat ring deforms into the ball opening, it forms a bulge in a sector of the seat ring. This bulge, in turn, pushes the ball member off centre and forces it to cut or distort the downstream seat. Such downstream seat ring distortion causes it to leak at both high and low pressures.

The ball valve A with seat assemblies B described in detail hereinabove is thought to provide a substantial improvement over those arrangements previously known in the art. Its design permits the seat assemblies to be flexible and deflect when acting as a downstream seat but to be rigid when acting as an upstream seat. The assemblies are spring-loaded at initial assembly to maintain sealing at low pressures. The seat ring and ball movements are proportioned to release the upstream seat ring from sealing against the ball at high pressures. The upstream seat is supported by a reinforcing ring during valve opening to prevent distortion. Also, this reinforcing ring provides a large bearing support area to prevent the upstream seat ring from shearing at the valve body shoulder or being otherwise displaced from its proper location within the valve.

Figure 8 shows a number of design modifications or features which may be advantageously incorporated into seat assemblies B. Such modifications accommodate component machining and valve use as will become apparent. Moreover, the modifications may be individually adopted to use and are not dependent on each other for successful seat assembly operation. For ease of illustrating these alternative design features, like components are identified by like numerals with a primed (′) suffix and new components are identified by new numerals.

In Figure 8, counter bore end wall 78′ extends further inwardly into main valve body section 12′ and the radially outwardly extending flange is absent from reinforcing ring 100′. Thus, the inner end face or wall 150 of the reinforcing ring abuts counterbore end wall 78′ to positively establish an axial innermost or home position therefor.

In addition, third surface 124′ of seat ring 102′ does not include a stepped area as shown and described above with reference to the preferred embodiment. Rather, the seat ring third surface is continuous over the annular extent thereof and is adapted to directly engage reinforcing ring first surface 110′.

The above two modifications are primarily production oriented. That is, each eliminates a machining step which is otherwise required for reinforcing ring 100′ and seat ring 102′.

With continued reference to Figure 8, seat ring first or ball-engaging surface 120′ also has a slightly modified conformation. As shown, the ball-engaging surface is designed to have a concave spherical surface concentric with the longitudinal axis of the seat ring itself and a radius equal to the radius of the ball member. Thus, when the valve is initially assembled, surface 120′ will substantially matingly engage the ball member surface and will remain in such substantial mating engagement during rotational flexure of the seat ring.

It is also possible for first or ball-engaging surface 120′ to have other radii of curvature, both larger and smaller than the radius of the ball member. Moreover, in some cases it may be desirable to configure the body of seat ring 102′ so that, in the free state thereof, such as is shown in Figure 8, ball-engaging surface 120′ is rotated slightly outward of the seat ring central opening. With this type of structure, the locus of the radii for surface 120′ is a circle concentric with the seat ring longitudinal axis. The aforementioned possible alterations for the seat ring ball-engaging surface are not a departure from the scope of the invention.

Finally, with regard to Figure 8, a groove 160 is provided in second surface 122′ of seat ring 102′. This groove extends inwardly into the seat ring body between the inner and outer diameters thereof, is continuous and extends around the entirety of second surface 122′. Groove 160 is particularly desirable for use with harder seat ring materials, such as acetal resins to increase flexibility and better accommodate the desired rotational flexure thereof as previously described. In addition to the particular groove configuration shown, other shapes and/or sizes therefor may be utilized to accommodate still other types of seat ring materials and/or valve parameters. Still

further, groove 160 may also be incorporated into seat rings constructed from softer materials, if desired to accommodate a particular valve application or design.

Other modifications not specifically shown in the drawings may be readily incorporated into seat ring assemblies B without departing from the scope of the invention. For example, it is possible to form axial flange 130 (Fig. 2) of seat ring 102 at the inside diameter thereof as opposed to the preferred position at the outside diameter. Another example resides in the specific orientation of seat ring second surface 122. As shown in the drawings, this surface tapers inwardly into the seat ring body from the outside diameter towards the inside diameter. This taper angle may be varied as deemed necessary and/or second surface 122 may be disposed normal to the seat ring axis so as to be generally parallel to the associated valve body shoulder. It may also be desirable to slightly modify the relative dimensional characteristics between the seat rings, reinforcing rings and disc springs to accommodate particular operational requirements.

Still further, and in some applications of the valve, it would be possible to entirely eliminate use of reinforcing rings 100 in seat assemblies B. In that case, forward or inward movement of the seat rings into valve body passageway 20 would be limited by, for example, engagement of the seat ring third surfaces with the end walls of the passageway counterbores. However, elimination of the reinforcing rings will reduce the pressure ratings attributable to the valve due to increased potential for upstream seat ring displacement and/or distortion which could result in damage to the downstream seat. This could be compensated to some extent by modifying the dimensional relationships between other of the remaining components. Nevertheless, the advantageous relationships between the ball member seat rings and disc springs as described above would still be obtained during valve use.

CLAIMS

1. A ball valve comprising a valve body having a generally cylindrical fluid flow passageway; a ball member disposed in said passageway and mounted for selective rotation between valve-opened and closed positions with said ball member being shiftable generally axially in said passageway under fluid pressure conditions, at least when said valve is in said closed position; a pair of annular seat rings disposed in said passageway on opposite sides of said ball member between said ball member and an associated valve body shoulder; and an annular disc spring interposed between each seat ring and its associated shoulder for continuously urging said seat rings towards sealing engagement with said ball member; each seat ring having a first continuous surface generally facing said ball member and adapted for positive sealing engagement therewith and a second surface generally facing the associated shoulder with the respective disc spring interposed between each seat ring second surface and its associated shoulder; each disc spring having a generally frusto-conical configuration in its unstressed condition with its smaller diameter end pointing towards said ball member and being sized so that, when said ball member, seat rings and disc springs are assembled between said shoulders, said seat ring first surfaces sealingly engage the surface of said ball member with said seat rings being rotatably flexed slightly outwardly of each other and with said disc springs being partially stressed towards a flattened configuration for continuously urging said seat ring first surfaces towards engagement with said ball member; and so that, when said ball member is axially shifted in said passageway towards one of said valve body shoulders in response to fluid pressure acting thereon in said valve-closed position, the seat ring associated with said one shoulder (the downstream seat ring) is further rotatably flexed towards said one shoulder with the first surface thereof remaining in sealing engagement with said ball member and the disc spring associated with said downstream seat ring is further stressed towards a flattened configuration, the other seat ring (the upstream seat ring) being rotatably flexed towards said ball member in the direction of shifting thereof under the influence of its associated disc spring in order that said upstream seat ring first surface will be urged towards continued contact with said ball member.

2. A valve as claimed in claim 1, wherein the downstream seat ring may be rotatably flexed by shifting movement of said ball member in engagement with the downstream seat ring first surface to a position where the associated disc spring is stressed to a substantially flattened configuration and said ball member has been correspondingly moved away from all contact with said upstream seat ring first surface.

3. A valve as claimed in claim 2, further including a pair of reinforcing rings positioned in said passageway on opposite sides of said ball member and axially inwardly of said seat rings, each reinforcing ring being located in a desired axial position in said passageway, a first surface facing an associated one of said valve body shoulders and a second surface generally facing said ball member in a spaced relationship therefrom, said reinforcing ring first surface providing a rigid bearing surface for the associated seat ring to prevent seat ring distortion and displacement in said passageway.

4. A valve as claimed in claim 3, wherein said passageway is counterbored a predetermined axial distance from each of said shoulders with each counterbore having an inner end wall, said reinforcing rings having at least a portion thereof received against the end wall of the associated counterbore to locate the reinforcing rings in the desired axial positions.

5. A valve as claimed in claim 4, wherein each reinforcing ring has a radially outward extending

flange dimensioned to engage the end wall of the associated counterbore and each seat ring further has a stepped region in the surface thereof disposed adjacent the associated reinforcing ring, said reinforcing ring first surface being receivable in said stepped area.

6. A valve as claimed in any preceding claim, wherein, upon initial valve assembly, said disc springs are compressed to a configuration equal to more than one half the allowable compression between the fully unstressed and fully stressed configurations.

7. A ball valve comprising: a valve body which has a centrally disposed generally cylindrical passageway; a ball member disposed in said passageway and having a fluid flow opening therethrough, said ball member being mounted for rotation about an axis generally normal to said passageway between valve-opened and closed positions to control fluid flow therethrough; a pair of radially inwardly extending shoulders in said passageway disposed generally equidistantly from said ball on opposite sides thereof, each of said shoulders being circumferentially continuous and having a surface facing said ball generally normal to said passageway; a pair of reinforcing rings fixedly positioned axially in said passageway on opposite sides of said ball, said reinforcing rings each having a central opening, a first surface facing an associated one of said shoulders and a second surface generally facing said ball member in a spaced relationship therefrom; a seat ring member interposed between each shoulder and its associated reinforcing ring, each of said seat rings having a central opening, a first continuous surface facing said ball member, a second surface generally facing the associated shoulder and a third surface engageable with the associated reinforcing ring first surface, said seat ring first surfaces being adapted for positive sealing engagement with said ball member; and a disc spring interposed between each seat ring second surface and the associated shoulder, each disc spring having a central opening and a generally frusto-conical configuration in an unstressed condition, said disc springs being positioned with their smaller diameter ends pointing towards said ball member and sized so that, when said ball member, reinforcing rings, seat rings and disc springs are assembled between said shoulders, said seat ring first surfaces sealingly engage the surface of said ball member and cause flexure of said seat rings slightly outwardly of each other in response to such engagement and so that said disc springs are partially stressed towards a flattened condition for continuously urging said first surfaces towards engagement with said ball member.

8. A valve as claimed in claim 7, wherein said body is provided with removable end fittings which define said shoulders.

9. A valve as claimed in claim 7 or 8, wherein each of said seat rings has an axially extending circumferential flange at the second surface thereof for locating the associated disc spring relative thereto.

10. A valve as claimed in claim 7, 8 or 9, wherein the central openings in each disc spring and in the associated seat ring are substantially equal in size and smaller in size than the central opening in the associated reinforcing ring.

11. A valve as claimed in any of claims 7 to 10, wherein said passageway is counterbored a predetermined axial distance from each of said shoulders with each counterbore having an inner end wall, said reinforcing rings having at least a portion thereof received against the end wall of an associated counterbore for fixedly locating said reinforcing rings axially in said passageway.

12. A valve as claimed in claim 11, wherein each reinforcing ring has a radially outwardly extending flange dimensioned to engage the end wall of the associated counterbore and each seat ring third surface has a stepped region for receiving the associated reinforcing ring first surface therein.

13. A valve as claimed in any of claims 7 to 12, wherein said ball member is axially movable in said passageway when said valve is in said closed position to accommodate ball member shifting towards a downstream one of said shoulders in response to fluid pressure, the downstream seat ring associated with said one shoulder being further flexed in response to shifting of said first surface thereof to further compress its associated disc spring, the other or upstream seat ring being flexed in the direction of movement of said ball member under the influence of its associated disc spring in order that the first surface thereof will be urged towards the continuous contact with said ball member.

14. A valve as claimed in claim 13, wherein the downstream seat ring may be flexed to a position wherein its associated disc spring is moved to a substantially flattened condition with said ball member being moved away from contact by said upstream seat ring first surface, the reinforcing ring associated with said upstream seat ring providing a rigid bearing surface therefor to prevent distortion and displacement of said upstream seat ring in said passageway.

15. A valve as claimed in claim 14, wherein flexure of said seat rings is a rotational or rolling type flexure.

16. A valve as claimed in any preceding claim, wherein said seat rings are constructed from a resilient material.

17. A valve as claimed in any preceding claim, wherein each seat ring second surface has a relief groove extending therearound to facilitate flexure

of the seat ring.

18. A ball valve constructed and adapted to operate substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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